Nearshore Wave-Topography Interactions

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LONG-TERM GOAL

My long term goal is to develop a predictive understanding of the fluid dynamics of a random wave field shoaling over the complicated bathymetry of a natural beach, and the response of the beach to those overlying wave and current motions.

OBJECTIVES

Our principle focus in recent years has been on nearshore variability at time scales of days to years (the time scales for which predictions become useful for society). Bathymetric evolution is generally significant at these scales and behavior of the system becomes more dependent on the nature of feedback within the sysem than on the details of component processes. Our primary objective is to understand the link between system feedback mechanisms and system behavior.

APPROACH

In contrast to the benign behavior expected of systems with weak or no feedback, strong feedback systems can exhibit surprising and complex variability. Quite often the phenomenology featured in models is not representative of that observed in nature. Thus a key element of our program has been the collection of long time series of relevant system information at nearshore sites that span the relevant parameter space. This has been accomplished through the Argus Program of video remote sensing stations. Criteria for the Argus program are to provide ongoing data in a robust, low-cost way while providing broad access using a suite of straight-forward analysis tools.

WORK COMPLETED

A tenth Argus station was installed this year at Teignmouth, England (Figure 1). This site includes a steep beach of coarse sediment facing a bi-modal English Channel wave climate, adjacent to a macro-tidal tidal inlet. The combination forms an interesting nonlinear dynamical system in which the ebb delta forms, extends and breaks off in a four year cycle that balances wave and tidal influences. Teignmouth is also the site of the second Coast3D European field experiment, in which we will participate.

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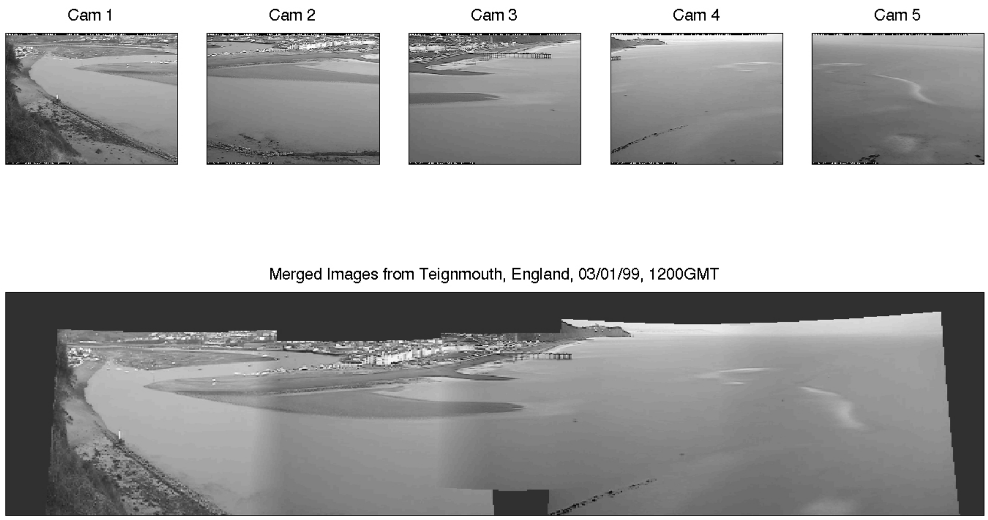

1. Example time exposure images from the five cameras at Teignmouth, England,and a panoramic merged image. The shoals (breaking pattern at right) are an ebb tidal delta, influenced by English Channel waves. The shoals grow steadily until they become unstable and break off (example in the far field) and progress to shore (features along shoreline), usually on a 4 year cycle. Thus, these features are an example of a natural nonlinear dynamical system.

We have now completed the upgrade of all Argus stations but one (Hawaii) to the new SGI hardware. This change has allowed a tremendous increase in power and capability and has substantially eased problems of system management. At this stage, the suite of Argus stations is essentially complete. With the possible exception of a low energy reflective site like the Gulf of Mexico or a steep cobble site, the current set of 10 stations spans a wide range of wave heights, periods, beach slopes and tidal ranges. These stations collect imagery hourly, reporting back immediately (three stations) or each night.

We have also slowly moved to a greater use of pixel intensity time series data. In this mode, Argus stations can be programmed to collect 2 Hz. data of fluctuating radiance at a user-determined array of pixel locations. For example, figure 2 shows the camera 3 array of pixels that are currently being collected in conjunction with the SHOWEX experiment at Duck, NC. All details of these collections can be remotely controlled and altered, allowing adaptation of sampling strategy to changing conditions.

2. Example image from Duck, NC. Red dots show the individual pixels at which time series data are being collected as part of the SHOWEX experiment. At each pixel, 68 minute time series of 2Hz data are collected every two hours. The 872 pixels in this image (coupled with 897 collected simultaneously from the adjacent camera) form arrays that are designed to measure celerity, wave angle, and longshore current.

RESULTS

This has been a year of publication catch-up, as a number of near-complete pieces of work have finally been either submitted or published. A synthesis of the statistics of infragravity band runup has finally been published [*Holland and Holman*, 1999], showing both a complete lack of prefered frequency selection (required for infragravity bar-generation models) and developing analytic spectral forms for longshore wavenumber.

Papers describing two new phenomena have been submitted and are in review. One describes the statistics and kinematics of Shoreward Propagating Accretionary Waves (SPAWs), isolated stranded mounds of sand that transit the trough of inner bars over several weeks to merge with the shoreline [*Wijnberg and Holman*, in review].

Similarly, the statistics and kinematics of short wavelength (50m) oblique sand bars has been documented [*Konicki and Holman*, in review], and a model for their formation through an instability of the longshore current/bottom topography system has been tested [*Barcilon and Lau*, 1973]. There was no evidence to support the instability model, perhaps due to the additional complication of an energetic wave field instead of a simple longshore current system.

A paper describing the capability of celerity-based techniques to estimate underlying nearshore bathymetry has finally been submitted [*Stockdon and Holman*, in review]. Performance as good as 6% resulted from the use of low wave conditions, away from the breaking onset region on the bar flank. A second paper has been submitted describing the performance of the Coastal Profiling System for measuring bathymetry from a jet ski [*J.M.Cote et al.*, in review]. Errors were usually less than 10 cm, a target for the system.

IMPACT/APPLICATION

This research has direct application in both civilian and defense communities. Data and understanding acquired in the Argus program will be very relevant to issues of battlespace environment characterization, particularly for one week of longer look-aheads. Because the Argus program includes 10 sites spanning the full range of beach types, the understanding developed should be relevant to more than just Duck-like coasts. Techniques developed to quantify EO imagery for the extraction of geophysical variables can be readily applied to moving platform remote sensing, with the addition of only frame-dependent image navigation.

TRANSITIONS

Argus technology has been transitioned to NRL-SSC in a program run by Dr. Todd Holland. As part of this ongoing collaboration, a new Argus station was installed at Camp Pendleton for ongoing and special purpose collections. We continue collaboration with the U.S. Army Corps of Engineers both through Bill Curtis at Vicksburg and through the FRF on a variety of Argus issues. Skills and ideas in handling EO data developed due to Argus interest have lead to the PI spending substantial lengths of time either at Navoceano, or at OSU, working directly on problems of implementation of nearshore remote sensing to Naval needs.

RELATED PROJECTS

1 - Joint work with Dr. Todd Holland, NRL-SSC
2 - Collaboration and data sharing of pixel time stack data with Dr. Jim Kaihatu or NRL-SSC
3 – Collaboration with Craig Cobb of the WSC at Navoceano on nearshore remote sensing
4 – LRS program collaboration
5 – NICOP joint program with several European groups
6 – NICOP joint program with Dr. Graham Symonds of Australia
7 – Joint work with Bill Curtis of US Army Corps
8 – Numerous collaborations with the Field Research Facility
9 – participation in SHOWEX

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Wijnberg, K.M., and R.A. Holman, Shoreward propagating accretionary waves in the nearshore, *Journal of Geophysical Research*, in review.

PUBLICATIONS

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